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Proposal for further tests on the lateral bracing requirements of beams, Lehigh University, (January 1961)

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205H PHASE III

PROPOSAL FOR FURTHER TESTS ON THE LATERAL BRACING REQUIREMENTS OF BEAMS

1. Introduction

In a proposal dated March 18, 1960, an experimental program was submitted

a.) to study the post-buckling behavior of wide-flange beams subjected to uniform moment,

b.) to determine the maximum bracing spacing which will still permit the formation of a plastic hinge, and

c.) to evaluate the required strength and stiffness of the lateral bracing.

These proposed experiments will be completed in December 1960.

This present proposal contains an extension of the work covered by the previous one. The new program is mainly concerned with the study of practical problems in connection with lateral bracing.

In order to facilitate the explanation for the new experiments, the program which has just been completed will be described briefly: A schematic view of the test set-up is shown on the top of Table 1. The center span, subjected to uniform moment, was the critical span. For all experiments the length of the adjacent spans was equal to the length of the critical span.

The first series of experiments consisted of six tests. These tests are listed in Table 1. The lateral supports at points B and C (See sketch in Table 1) permitted no twisting or lateral movement of the test beam at these points, thus furnishing known support conditions. In these experiments the length of the critical span was varied from 35 r_y to 50 r_y in order to study the effect of the variation of the unsupported length on the post-buckling behavior of beams. These tests showed that the optimum unsupported length under uniform moment is 40 r_y. With a bracing spacing of 40 r_y the beams delivered a full plastic hinge with a rotation capacity (ϕ/ϕ_y) of about 12 or more. Final failure was not triggered by lateral buckling but by the local buckling of the compression flange.

The second series of tests were performed on beams with a critical span of 40 r_y, and the lateral supports at B and C were replaced by purlins welded to the outside face of the compression flange. These purlins were continuous over the beam, and pin-ended at their far ends. The purpose of these experiments was to evaluate the required strength and stiffness of the lateral braces. In three of the tests the purlin size was varied, and in three of the tests the lengths of the purlin were varied. From these experiments it can be concluded that purlins of usual proportions are ? able to restrain the braced member to form a plastic hinge, if the purlins are spaced at 40 r_y.

Currently the test data are being analyzed. Detailed information will be included in two forthcoming reports. The moment vs. curvature curves for all the tests are shown in Figs. 1 and 2 respectively.

2. Objectives

The main variables involved in the investigation of lateral bracing requirement are:

- a.) Unbraced length.
- b.) Strength and stiffness of purlins.
- c.) Beam size.
- d.) Length of adjacent spans.
- e.) Method of purlin attachment.
- f.) Dead weights on purlins.
- g.) Type of purlins.

h.) Number of spans.

i.) Moment gradient.

The tests in the previous proposal were aimed at the determination of the effect of the first two variables. For a more detailed study of the problem it is desirable to perform additional tests. Twelve further experiments are recommended in the present proposal in order to evaluate the effect of beam size, length of adjacent spans, method of purlin attachment, dead weights on purlins and type of purlins.

3. Proposal

It is proposed to perform twelve experiments on wide-flange beams. Table 3 lists the test numbers, beam and purlin sizes, and the purpose of each test. The test set-up, the data, and the instrumentation will be essentially the same as in the past test series with some minor changes. Each test will consist of a beam which is laterally braced at the ends and at two intermediate points. The latter braces consist of purlins which are attached to the compression flange* of the beam, and are pinned at their far ends.

*For some of the proposed tests the braces are connected to the most compressed portion of the web.

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The first experiment (LB-21) is aimed at the evaluation of the effect of local buckling of the compression flange. In this test the critical and the adjacent span lengths will be 40 r_y. The test beam will be a 8B13 section, with the purlins being M2362 special sections (See Table 4 for description of the selected sections). It is intended to determine the influence of local buckling on the post-buckling strength of a beam which has a more critical flange proportion with regard to local buckling than the 10WF25 of the previous tests (for 8B13, b/t = 15.75; for 10WF25, b/t = 13.4). ?

The second and the third tests (LB-22 and LB-23) are designed to furnish information about the effect of the variation of the adjacent span length. The length of the critical span will be 40 r_y, for these tests. For test LB-22 the length of the adjacent spans is 60 r_y. This length is kept open for LB-23; it will be decided upon completion of test LB-22. The test beam and the purlins will be an 8B13* section and the M2362* sections respectively (See Table 4). The purlin length will be determined from the results of the previous test program. These purlins will be continuous over the beam which they brace. Loads what var?

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*This combination of sections may be changed if test LB-21 indicated unsatisfactory local strength of the flanges of 8B13.

will be applied to the test beam through the compression flange (Fig. 3).

The influence of transverse load on the purlins is studied in experiment LB-24 (See Fig. 4). The test beam will be a 10WF25 section, and the purlins will be 3I5.7 sections. (Table 4) The transverse load will be applied as dead-weight to the purlins.

A study of various purlin-to-beam connections is provided by test LB-25, LB-26, LB-27, and LB-28. The purlins, which will be of the same length as those in tests LB-22 and LB-23 are connected to the beam by the following methods:

LB-25 bolted to the outside face of the compression flange (Fig. 5a).

LB-26 the web of the purlin is bolted to two angles, and the angles are welded to the web of the beam (Fig. 5b).

LB-27 Same as LB-26 except that the purlins are cut such that after connection the outside flange surface of the beam and the purlins are in a horizontal level (Fig. 5c).

LB-28 welded to the outside face of the compression flange, and connected to the tension flange by angle struts (Fig. 5d).

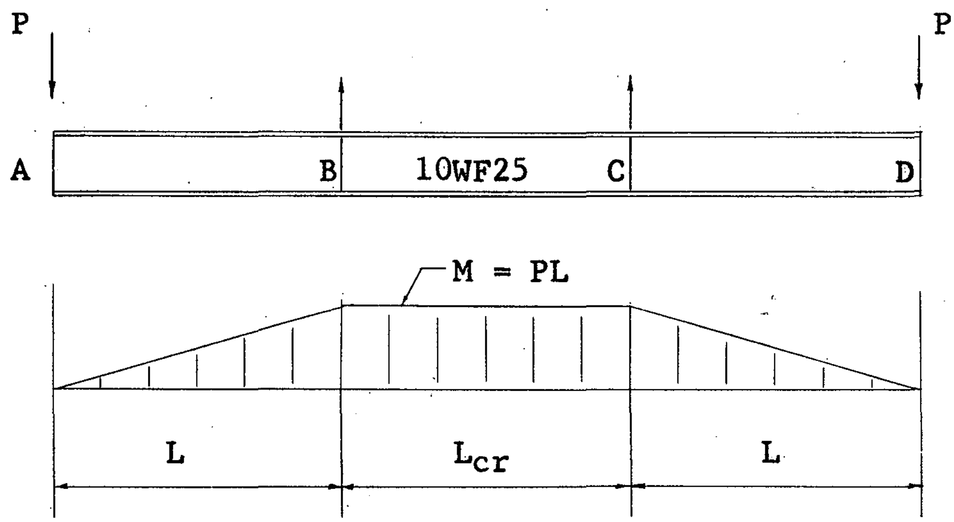
Four tests (LB-29, LB-30, LB-31 and LB-32) are planned for the study of open-web steel joists as purlins (See Fig.4). The beam specimens will be 10WF25 sections and the purlins are to be welded to the outside face of the compression flange of the test beam. The purlins will be 8S2 open-web joists (See Table 4). Details of connection are shown in Fig. 4. It is recommended to study the following variations based on these tests.

a.) Optimum length of purlins.

b.) Joists connected to the tension flange of the beam by struts, without stiffeners. (Same as test LB-28, Fig. 5d)

c.) Influence of dead weights on purlins.

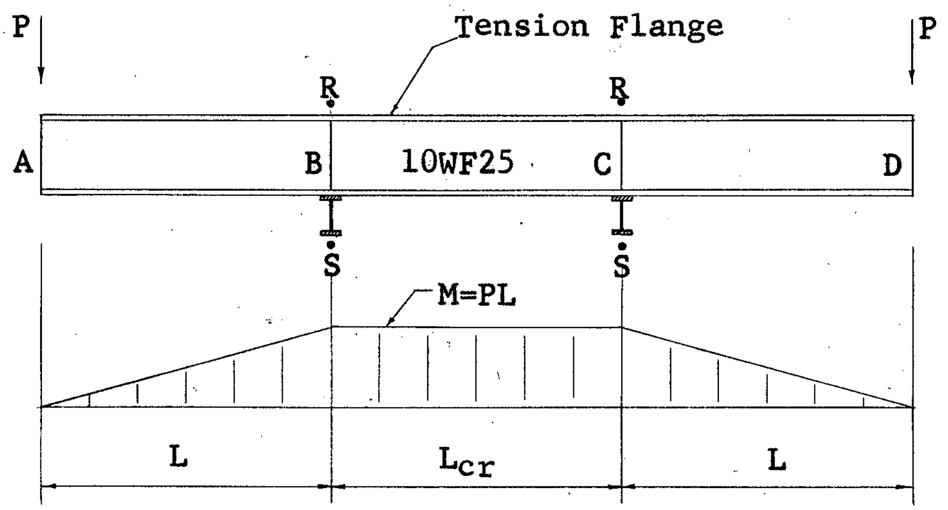
Supplementary experimental work will include coupon tests and residual stress measurements.



Lateral Supports at Sections A, B, C and D.

Test No.	L_{cr}	Remarks
LB-9	40 r_y	Movement of Lateral Support
LB-10	45 r_y	
LB-11	35 r_y	
LB-15	40 r_y	Retest of LB-9
LB-16	50 r_y	
LB-17	20 r_y	Determination of M_p

TABLE 1



• R — Points of Loading for LB-12, 13 and 14.

• S — Points of Loading for LB-18, 19 and 20.

Test No.	L_{cr}	Purlin Length	Purlin Size	Remarks
LB-12	40 r_y	84"	4 I 7.7	Loading through tension flange (position R).
LB-13	40 r_y	84"	3 I 5.7	
LB-14	40 r_y	84"	M 2362	
LB-18	40 r_y	84"	3 I 5.7	Loading through compression flange (position S).
LB-19	40 r_y	117"	3 I 5.7	
LB-20	40 r_y	150"	3 I 5.7	

TABLE 2

Test No.	Beam Section	Purlin Section	Crit'l Span	Adja't Span	Remarks	Fig. No.
LB-21	8B13	M2362	$40r_y$	$40r_y$	Effect of beam size & local buckling.	3
LB-22	8B13	M2362	$40r_y$	$60r_y$	Influence of adjacent span length.	3
LB-23	8B13	M2362	$40r_y$	Open		3
LB-24	10WF25	3I5.7	$40r_y$	$40r_y$	Purlins with dead weights.	4
LB-25	10WF25	3I5.7	$40r_y$	$40r_y$	Method of purlin attachment.	5a
LB-26	10WF25	3I5.7	$40r_y$	$40r_y$		5b
LB-27	10WF25	3I5.7	$40r_y$	$40r_y$		5c
LB-28	10WF25	3I5.7	$40r_y$	$40r_y$		5d
LB-29	10WF25	8 S 2	$40r_y$	$40r_y$	Effect of different types of purlins, and methods of purlin attachment.	6
LB-30	10WF25	Open	$40r_y$	$40r_y$		6
LB-31	10WF25	Open	$40r_y$	$40r_y$		6
LB-32	10WF25	Open	$40r_y$	$40r_y$		6

TABLE 3

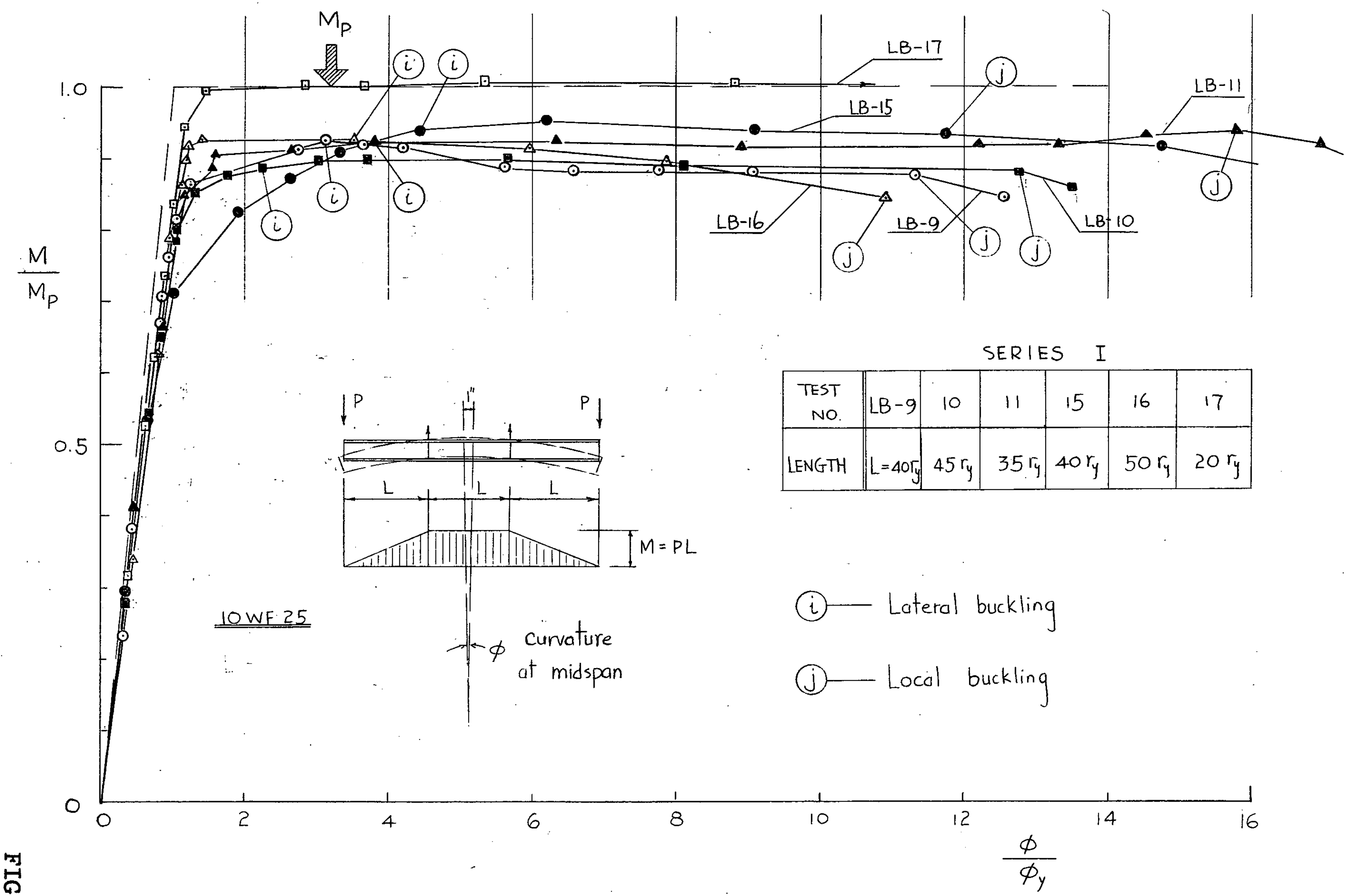
Sections	Section Properties	Reasons for Selection
10WF25*	b/t = 13.4 A = 7.35 sq. in. d/w = 40.0 r_y = 1.31	To keep beam section the same in order to evaluate the difference between the various methods of purlin attachment.
8B13*	b/t = 15.75 A = 3.83 sq. in. d/w = 34.1 r_y = 0.99	To check local buckling effect and to test longer adjacent span length in the current test set-up.
3 I 5.7*	d = 3" r_y = 0.53 A = 1.64 sq. in.	To keep purlin section the same as before in order to differentiate the influence between the various methods of purlin attachment.
M2362**	d = 1.625" lb/ft = 3.73 A = 1.04 sq. in. r_y = 0.174	Bracing members for 8B13 beams in order to keep the beam-purlin assembly within the range of practical proportions.
8 S 2***	weight = 4 lb/ft depth = 8" A = 0.818 sq.in. (for hot-rolled chords) A = 1.043 sq.in. (for cold-formed chords)	To check the adequacy of using open-web joists as purlins.

TABLE 4

* AISC Steel Construction Handbook.

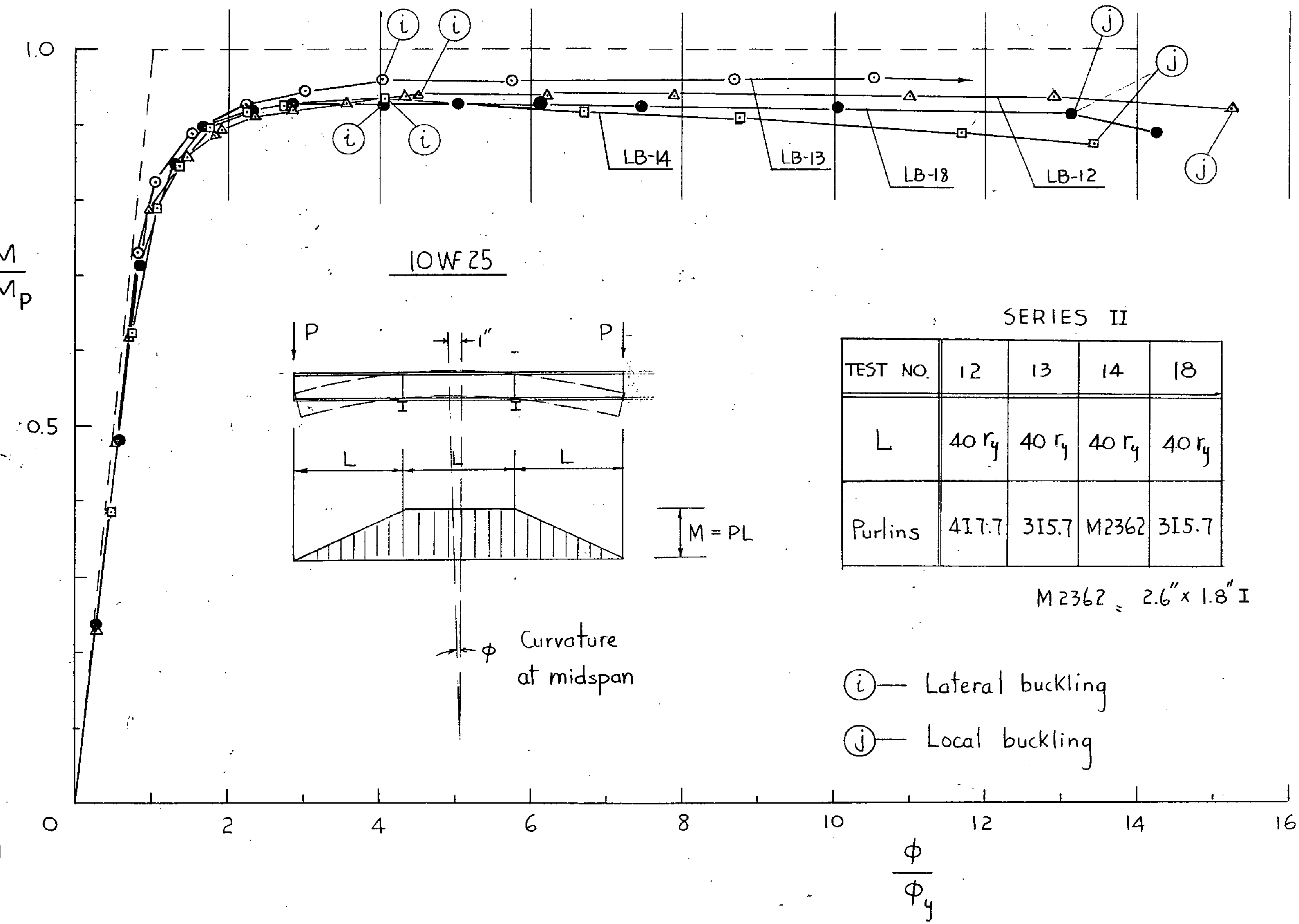
** A small I shape section fabricated by Bethlehem Steel Company.

*** See Bethlehem Open-Web Steel Joists Pamphlet AIA File No. 13g.



TEST NO.	LB-9	10	11	15	16	17
LENGTH	$L = 40 r_y$	$45 r_y$	$35 r_y$	$40 r_y$	$50 r_y$	$20 r_y$

FIG. 1



TEST NO.	12	13	14	18
L	40 r_y	40 r_y	40 r_y	40 r_y
Purlins	417.7	315.7	M2362	315.7

FIG. 2

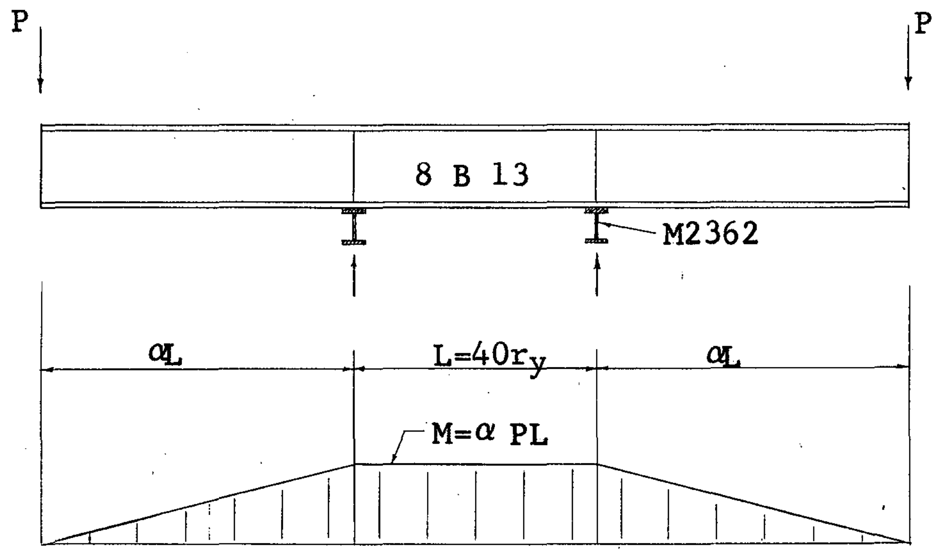


FIG. 3 Test LB-21 α=1 (Check beam size and flange local buckling.)

LB-22 α=1.5 (Check infl. of adjacent span length.)

LB-23 α open (Check infl. of adjacent span length.)

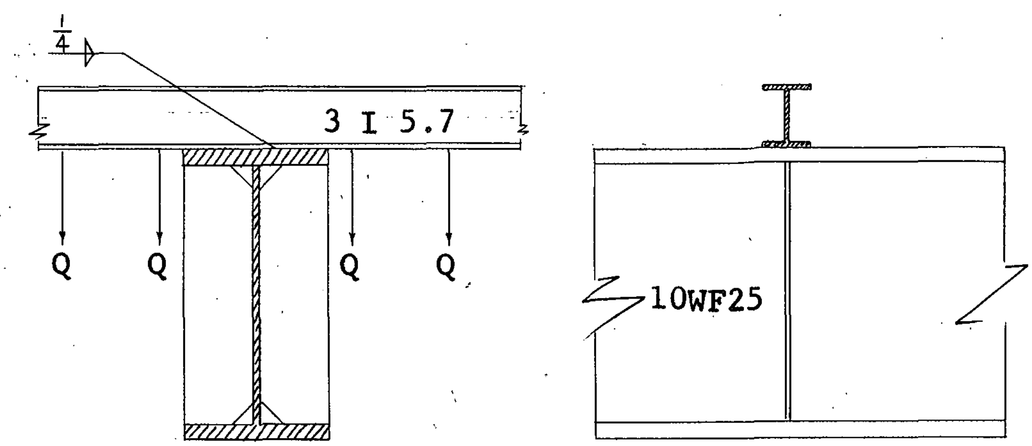


FIG. 4 Test LB-24 Test with dead weights on purlins.

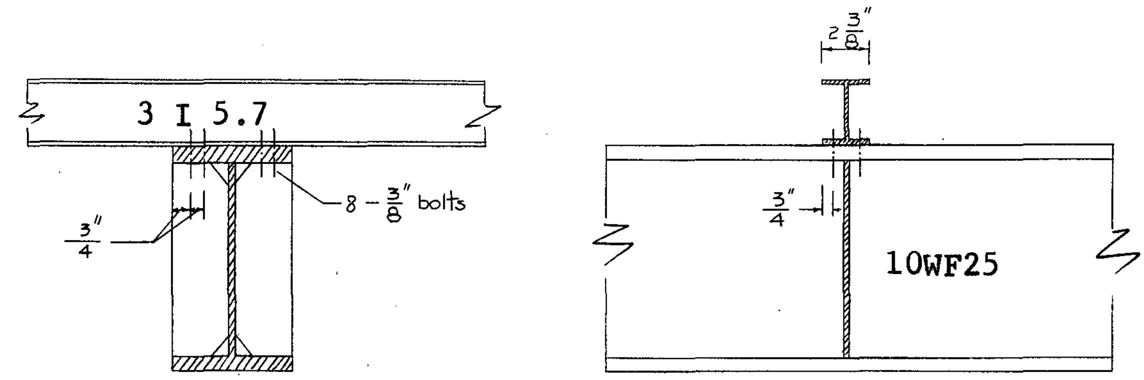


FIG. 5a LB-25 Continuous purlins bolted to the compression flange of beam.

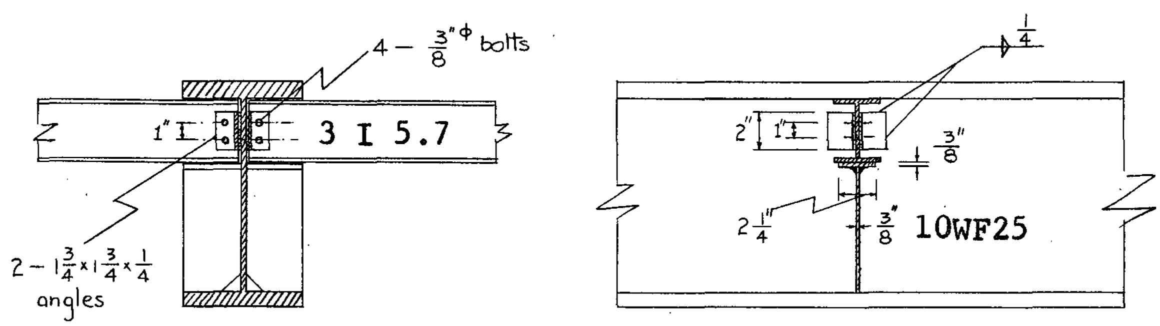


FIG. 5b LB-26 Purlins discontinuous. Connected to the web of the beam by angles.

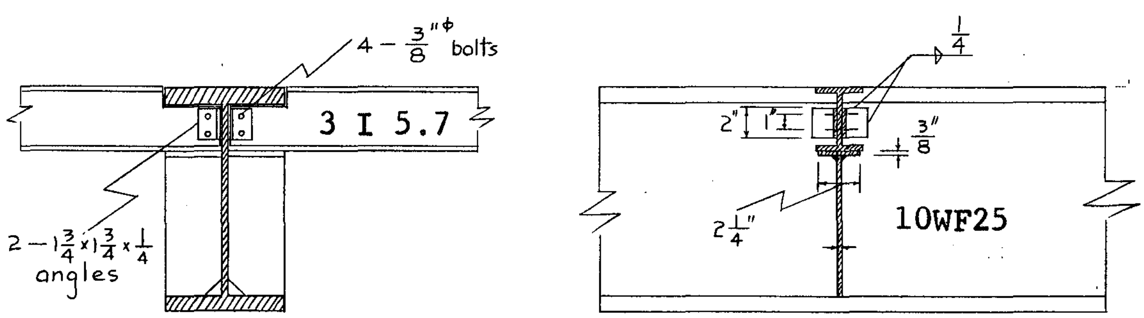


FIG. 5c LB-27 Purlins discontinuous. Connected to the web of the beam by angles.

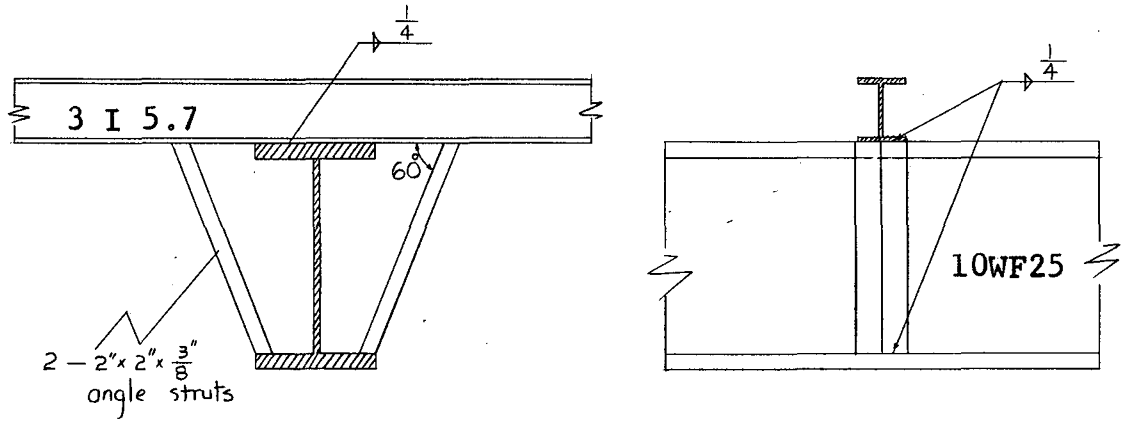


FIG. 5d LB-28 Beam without stiffeners. Purlins connected to the tension flange of the beam by angle struts.

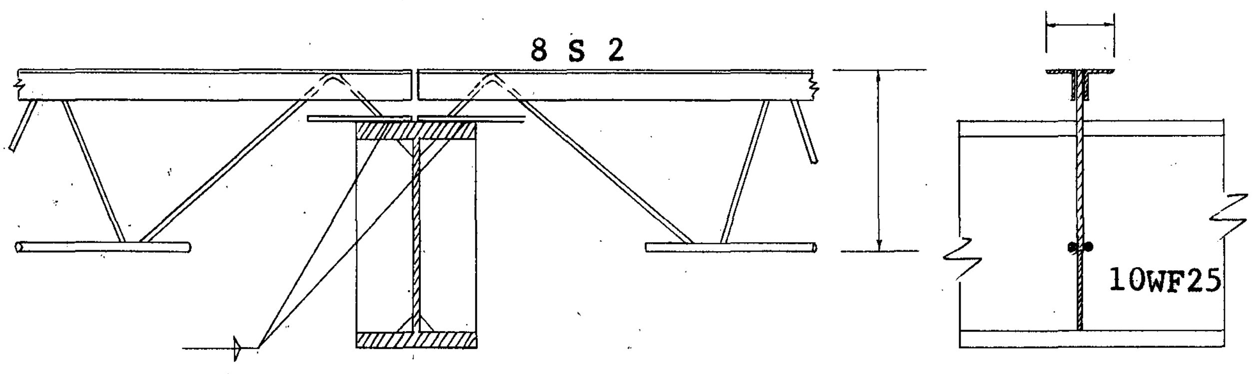


FIG. 6 LB-29, 30, 31, and 32
To check the adequacy of using open-web joists as purlins.